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Chapter 7

Advances in Radiometry for Ocean Color

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7.1 INTRODUCTION

Under natural illumination from sunlight, the optical properties of seawater and dissolved and suspended materials result in spectrally dependent absorption, scattering, and fluorescence. Phytoplankton absorb blue light strongly and reflect predominantly green light, whereas pure water reflects predominantly blue light. The ocean color can, therefore, be related to phytoplankton concentration, and global ocean color measurements by satellite sensors can give information regarding the concentration and distribution of microscopic marine plants.

Phytoplankton utilize carbon dioxide from the ocean/atmosphere system to conduct photosynthesis and understanding this interaction is important to climate research. Satellite observations are used to produce global assays of biomass and carbon production in the world's oceans; this information provides a more accurate understanding of the Earth's carbon balance and the relationship between the ocean’s productivity and the Earth's climate.

For quantitative studies of the ocean, the optical properties are related to physical and biogeochemical data products such as the concentration of phytoplankton chlorophyll *a* through bio-optical algorithms. Factors influencing the uncertainty in final data products, such as phytoplankton chlorophyll *a* concentrations, are roughly divided into environmental and radiometric components. Environmental factors include perturbations of the incident radiance field associated with clouds and the wind-roughened sea surface, undetermined variations in the water inherent optical properties (IOP) and bi-directional reflectance distribution function (BRDF), ambient temperature, solar zenith angle and instrument self-shadowing. Furthermore, the optical properties of the phytoplankton depend on species composition as well as such environmental factors as ocean temperature and salinity. Understanding the influence of environmental factors on ocean color data products is a very complicated problem that is beyond the scope of this work.

In this Chapter, we focus on the radiometric components of the total uncertainty in ocean color measurements and describe recent advances that help reduce those uncertainty components. Radiometric quantities of interest in ocean color include the water-leaving spectral radiance $L_W(\lambda)$, the downwelling spectral irradiance incident at the sea surface, $E_S(\lambda)$, and remote sensing reflectance (Mueller, Fargion and McClain 2003). Measurements of $E_S(\lambda)$ and vertical profiles of $L_u(z, \lambda)$, the upwelling radiance at depth z, are often extrapolated to the sea surface to derive $L_W(\lambda)$ and additional parameters such as the diffuse attenuation coefficient (Mueller 2003; Clark *et al*. 2003).